20. Colorado Plateaus: (a) High Plateaus of Utah; (b) Uinta Basin; (c) Canyon Lands; (d) Navajo section; (e) Grand Canyon section; (f) Datil section.
21. Basin-and-range province: (a) Oregon lake section; (b) Nevada Basin; (c) Sonoran Desert; (d) Salton Trough; (e) Mexican Highland; (f) Sacramento section.

Pacific Mountain System.—

22. Sierra-Cascade Mountains: (a) Northern Cascade Mountains; (b) Middle Cascade Mountains; (c) Southern Cascade Mountains; (d) Sierra Nevada.
23. Pacific Border province: (a) Puget Trough; (b) Olympic Mountains; (c) Oregon Coast Range; (d) Klamath Mountains; (e) California Trough; (f) California Coast Ranges; (g) Los Angeles Ranges.
24. Lower Californian province.

[1] An excellent account of these attempts has been given by Joerg, W. L. G., *Assoc. Amer. Geogr., Annals*, **4**, 1914 (55–84), 22 maps.

[2] Fenneman, N. M., *Assoc. Amer. Geogr., Annals*, **4**, 1914 (84–134), 3 maps.

ON THE COMPOSITION OF THE MEDUSA, CASSIOPEA XAMACHANA AND THE CHANGES IN IT AFTER STARVATION

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Communicated by A. G. Mayer, December 13, 1916

Cassiopea may be divided into three distinct parts; mouth-organs, umbrella and velar margin. Since these three parts differ not only morphologically, but also in their absolute weights, as well as in the relative amount of cellular and non-cellular constituents, it was thought desirable to study the normal growth of these parts in order to determine whether the starving Cassiopea loses weight uniformally or whether the loss is dissimilar in the three parts concerned. A large number of observations were also made on the undivided Cassiopeas.

The observations made on the normal Cassiopea may be summarized as follows: (1) Relative weights of mouth-organs, umbrella and velar margin differ somewhat according to the size of the entire body. (2) The water content of the entire body, as well as of different parts, is practically identical throughout the animal's life cycle, so far as followed. (3) The percentage of nitrogen in the solids is highest in the smallest medusa, and the values decrease progressively with increasing body weight. The percentage of nitrogen is highest in the velar margin and decreases in the mouth-organs and umbrella in the order named.

All these observations are interpreted as indicating that in the structures in which the cellular elements are abundant, the nitrogen content tends to be high. (4) The ash content, like the water content, is probably the same not only in the Cassiopea as a whole, but also in each of the three parts throughout the life cycle. The next step was to determine the changes in Cassiopea as the result of starvation.

Mayer ('14) reported (*Carnegie Inst. Publ.*, No. 183, pp. 55–84) that in Cassiopea the percentage of nitrogen to the total solids remains constant during the entire period of starvation. Mayer infers from this that "no appreciable chemical change occurs in the composition of its body, and that there is no appreciable selective use of different substances at different times during the progress of starvation." This is remarkable since the starving mammalian body reveals a totally different relation owing to the rapid disappearance of reserve substances such as carbohydrates and fats during the earlier period of starvation, followed by a slow consumption of protein substances later. Thus the starving mammalian body gives different percentage values for the nitrogen at different periods of starvation, especially in the earlier stages.

At present my observations are limited to the composition of the Cassiopeas at the end of the starvation experiment, while I reserve the question of progressive changes during the stages of inanition for the future.

For this purpose eight freshly caught normal Cassiopeas, having different body weights, were subjected to starvation. The starvation was accomplished by placing the animal in filtered sea water. The filtration was made with all the precautions adopted by Mayer ('14) and the water (4500 cc.) in the vessel was changed once every day. Briefly summarized the results of the observations made on the starved Cassiopea are as follows:

1. In general the smaller Cassiopea loses relatively more in weight than does the larger Cassiopea.

2. The percentage of water found in the entire body, as well as in the three different parts is nearly the same in all sizes of Cassiopea. However the values of water content in the starved, appears to be slightly higher than that found in the normal Cassiopea.

3. The nitrogen content of the entire body is higher in the smaller than in the larger Cassiopea, as in the case of the normal animals.

4. However the absolute amount of nitrogen found in the starved Cassiopea is considerably higher than in the normal having the same body weight. It was noted also that although high when compared with the normal, equal in weight to the starved animal, it is very low for the initial body weight of

the starved animal. This shows that the nitrogen also has been consumed during the period of starvation.

5. The nitrogen contents for the different parts of the body are similar in their relations to those found in the normal Cassiopea.

6. The loss in weight of the different parts is of such a character that their proportions in the starved remain similar to those in the normal Cassiopea.

From his data Mayer concluded that the percentage of nitrogen in the solids is independent of the period of starvation, and is practically identical with that obtained from the non-starved Cassiopea. I have however found, as stated above, that starvation tends to increase not only the percentage of nitrogen in the solids, but also that the absolute amount of nitrogen shows an increase when the starved Cassiopeas were compared with the normals having the same body weight.

The discrepancy between the conclusions drawn by Mayer and by myself is I believe due to the fact that Mayer's observations were limited to the larger Cassiopeas (body weights over 100 grams) in which the percentage of nitrogen in the solids shows little variation following the large variations of the body weight, while the variations in the nitrogen are quite noticeable in the Cassiopeas of smaller size. I may add here that the data given by Mayer in his table 2, show also a slight indication of a difference in the nitrogen content between the normal and starved Cassiopeas.

I have applied Mayer's law for the loss of weight in starving Cassiopeas to my own data, and found a satisfactory agreement between the observed and calculated values by the formula

$$Y = 83.58\ (1-0.05)^{x-1}$$

where Y represents body weight and X the number of days of starvation. My formula differs from that of Mayer in that I give the exponent as $(x-1)$ while Mayer gives it simply as x. He did not however consider the loss during the first day as being due to starvation, for during this time considerable quantities of undigested food and slime are discharged and the loss is thus excessive and irregular. Hence our formulas are in essential accord one with the other, both applying *after* the medusa has discharged its undigested food and its gastric cavity is empty. The lower body weight obtained, as compared with that calculated at an earlier period of starvation, was probably due to the frequent handling of the animal in order to determine the body weight daily.

A more detailed paper will appear in a volume of *Researches* from the Department of Marine Biology of the Carnegie Institution now in preparation.